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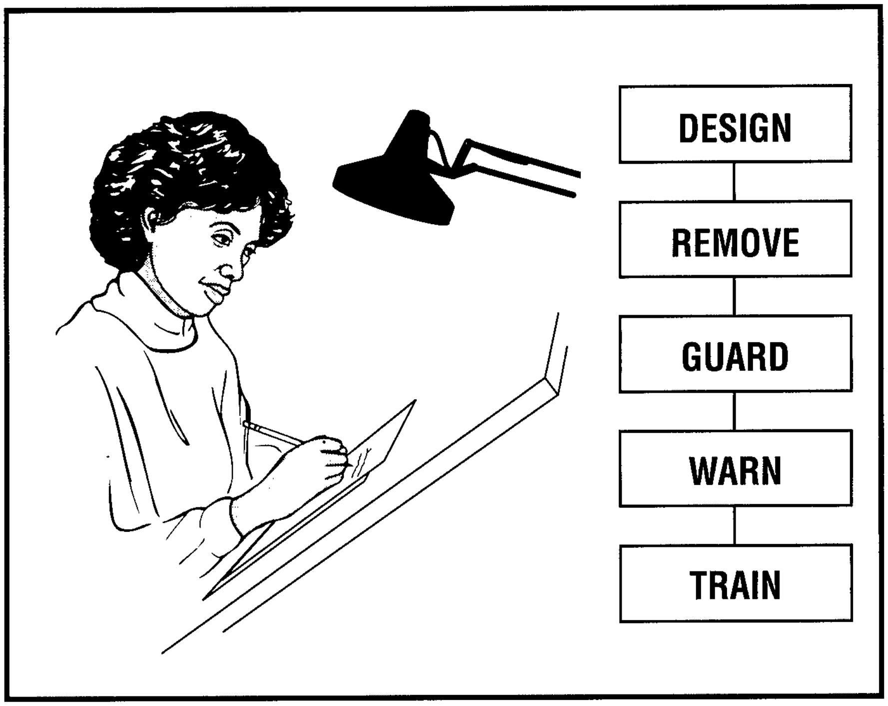
CSERIAC GATEWAY

PUBLISHED BY THE CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER

In this issue:

CSERIAC is a United States Department of Defense Information Analysis Center administered by the Defense Technical Information Center, Alexandria, VA, managed by the Human Engineering Division, Armstrong Laboratory, Wright-Patterson Air Force Base, OH, and operated by the University of Dayton Research Institute, Dayton, OH.



Five components of a model for the development of safer products. Illustration by Ronald T. Acklin.

Forensic Human Factors Psychology - Part 2: A Model for the Development of Safer Products

Julien M. Christensen[1]

Editor's Note: This is the second part of a two-part feature article. JAL

The model about to be described is a modification of an early systems safety model developed by the military services. It has been refined by such outstanding plaintiff's attorneys as Philo and Portner of Detroit. Portner and I found it useful in instructing engineering students in the ways of safe design practices. It can serve also as a useful guide in evaluating the hazard/risk characteristics of a particular product, system, or condition.

The model consists of five words: Design, Remove, Guard, Warn, and Train. The first four elements of the model are listed in order of precedence; for example, if reasonable to do so, safety *designed* into the product is preferable to the attach-

Continued on page 2

ment of *warnings*. This model will now be examined in more detail.

Design

The preferred method of achieving safety in a product is to design it as free of hazards as possible. This can be done in a number of ways. Examples include the use of redundancy on components whose failure presents an unacceptable hazard (e.g., automobile brakes), fail-safe designs, monitoring devices, interlocks, forgiving designs, etc.

The designer must design for the intended user and, if the product is to be made generally available to the public, this means the entire population. While no one expects an aircraft designer to design a jet fighter that anyone and everyone can fly, automobile designers are expected to design their vehicles so that any qualified person (presumably one who has a current driver's license) can drive it with safety. If this is not so, the vendor should restrict the sale of such vehicles. (If they tried, however, this might also get them in trouble. Perhaps they would be better off to offer free instruction on its handling qualities.)

As mentioned in Part 1, often in the past, designers, being unaware of the information that human factors psychologists have available on human capabilities and limitations, have designed with themselves or some mythical "average user" in mind. This, of course, ignores the vast individual differences among us: a ratio of *at least* 3:1 for most skills (Wechsler, 1952). Further, there is no assurance that the rationality of the user will be at all like that of the designer— "the foolish consumer," "the nut behind the wheel," etc. are no longer viable defenses in the courts of our land. Even if there were such a being as an average person, which there definitely is not, design for this mythical creature would often automatically eliminate 50 percent of the distribution. Further, while a designer may compute averages for single characteristics (e.g., height, weight, intelligence, etc.) the intercorrelations among most variables are such that most of the distribution would have disappeared after consideration of the first three or four. And successful interaction with most products usually requires many more than this number of characteristics and/or skills. Designers must learn to design for *ranges* of characteristics and abilities. In the military services, for example, this has usually meant, at least with respect to physical characteristics, design for the middle 90 percent of the critical distributions and, where feasible, individualized design for the remaining ten percent.

While it is now economically practical only to a limited extent (e.g., eyeglasses, dentures, etc.), in the future perhaps more and more products will be designed to "fit" the physical and mental characteristics of the individual. Adjustment factors may still be required because of learning, fatigue, other stressors, and other progressive factors.

Finally, while no one expects absolutely safe design for all products, the courts are making it increasingly clear that they expect designers to do all that they are *reasonably* able to do to present the user with a safe product. This includes adequate efforts to anticipate foreseeable misuse as well as intended use of the product. From the safety point of view, remarkable advances have been made in the design of what might appear to be some of our most hazardous products—aircraft, space vehicles, submarines, etc. Unfortunately, until very recently the application of these principles of safe design has not filtered down to where it is needed most, i.e., down to the myriad of products with which every man, woman, and child interacts every day. The argument that such attention to safe design would price one "out of the market" is specious. If properly integrated into existing design practices, principles and data from human factors and safety add little, if anything, to the cost of most products. Certainly any increment is inconsequential when considered in light of the cost to society of serious injuries,

Table 1
Guidelines for Guard or Safety Device Design
(Hammer, 1976; Reprinted with permission of Prentice-Hall)

- It must be safe under all conditions. If it fails, ceases to operate, or is open, the machine will immediately and automatically stop.
- Access to the danger zone must be prevented while the equipment is operating.
- It must impose no restrictions, discomforts, or difficulties for the worker.
- It must automatically move into or be fixed in place.
- It must be designed specifically for the machine, type of operations to be conducted, and hazards which are present.
- It must not require delicate adjustment for use or move out of adjustment easily.
- It must be impossible for an operator to bypass or inactivate it without simultaneously inactivating the equipment on which it is mounted.
- It should require minimum maintenance.
- It should not itself constitute a hazard.

deaths, ruined lives, or elimination forever of the joy to be realized from being a productive, participating member of society.

Remove

It has been observed that some cities have never had a collision between a train and an automobile. This is because city officials decreed that train tracks and automobile pavements would never cross at the same level—*the dangerous interface was removed.* (Incidentally, approximately 2,000 people are still killed at railroad crossings each year. Better planning at the time of initial construction would have saved many of these lives.) Apparently, the cost of redesigning and rebuilding all crossings is considered prohibitive. But it is yet another example of where society is willing to sacrifice human lives rather than to expend funds to save them. A human life is not "priceless"; decisions are constantly being made that confirm this contention.

Another example of the "remove" principle is the handling of hazardous materials (e.g., radioactive) with remote manipulators. Robots show promise of removing people from many jobs that are unduly hazardous.

Guard

If there is still residual hazard after the designers have done all they can reasonably do in the areas of *design and remove*, they have an obligation to develop *guards* that will prevent the user from inadvertent contact at the points of dangerous interface.

Hammer (1976) has developed a list of requirements for guards, as shown in Table 1. Essentially, a guard must be convenient, obviously essential, and must not impair operations. Otherwise, it is almost certain to be removed or defeated in some way.

It should be noted, however, that the Canadian expert, Jones (1973), has cautioned against undue reliance on guards. He suggests that guards may induce a false sense of security and may serve to reduce general awareness and competence.

Warn

If hazards still remain after designers have done all that is reasonable with respect to design, remove, and guard, then they have an obligation to *warn* the user of any remaining hazards.

Human factors psychologists can furnish considerable information regarding the technical details of warning devices and labels. A list of general requirements for warning devices is given in Table 2, which also includes some general and specific characteristics of people that should be considered in the development of warning devices.

Continued on page 4

Table 2
Guidelines for Warning Devices and Labels

I. General Requirements for Warning Devices
- A. Attract attention (if busy, bored, etc.).
- B. Tell what is wrong (and, if possible, what to do about it).
- C. Do not overwhelm to point where other critical duties are neglected.
- D. Can be tested without shut-down (e.g., "push-to-test").
- E. Fool-proof; no false alarms.
- F. Not too many—only critical functions—don't "cry wolf."
- G. Consistency across products.
- H. Redundancy (e.g., visual *plus* auditory).

II. Important General Human Characteristics
- A. Vision, audition, and tactual most commonly used senses for warning.
- B. Intermittent stimulation generally preferable to steady.

III. Specific Sensory Characteristics
- A. Visual warnings
  1. Color important because of convention (for example, "red" for danger and "yellow" for caution). But remember that approximately nine percent of the adult males (many fewer females) have some defect in their ability to perceive colors.
  2. Intermittent light generally better than steady. Rate: 2 to 10 flashes/sec. (4 flashes/sec. a good compromise). Duration of "on" period should be at least .05 sec.
  3. Light should be within a 30-degree cone of visual field.
  4. No other flashing lights in field of vision.
  5. Absolute intensity should be high (compared to other visual stimuli in the field).
- B. Auditory warnings
  1. Especially useful if eyes engaged elsewhere or person moving around.
  2. Signal characteristics
     - a. Generally best between 500 and 3000 Hertz.
     - b. Below 1000 Hertz for long distances.
     - c. Below 500 Hertz if physical obstacles in way.
     - d. Intermittency and warbling good.
     - e. Intense, sudden onset.
     - f. Uniqueness-discriminable from all other auditory signals.
     - g. Separate communication system, if possible.
     - h. If headphones, differences in phase or amplitude to two ears.
- C. Tactual
  1. Maximum sensitivity at approximately 250 Hertz.
  2. Sensitivity varies with temperature.
  3. Uniqueness sometimes valuable.
  4. Useful where vision and audition overloaded.

A set of rules for the development of warning labels is shown in Table 3. The proper key word (danger, warning, or caution) should be followed by information explaining why there is a hazard, what it is, what to do about it, etc. It is realized that users will not read the entire warning every time they use the product. However, they must be encouraged to read it the first several times they use the product—read it until they are so conditioned that simply seeing the key word will initiate the appropriate chain of safe responses.

While it must be admitted that one cannot invariably predict the specific response or pattern of responses that will ensue after an individual has been exposed to a warning device or a warning label, this does not relieve the designer of the responsibility to warn. It is imperative that candidate devices and/or labels be tested under representative conditions with representative users. In addition, if at all possible the hazards that are the objects of the warnings should be forcibly brought to the users' attention. This can often be done at time of sale. In addition, a manufacturer may wish to write to customers periodically, reminding them again of the hazards associated with the product and urging them to make sure that the original warnings are still affixed to the product and are still legible. It is the moral thing to do; in addition, it could be a source of enhanced goodwill for the company and might even result in repeat sales.

Table 3
Rules for Warning Labels

1. *Don't* try to correct poor design with labels.
2. Tell *what* to expect, *why* it is a hazard, and *what* to do about it.
3. Clear (comprehensible) and complete for *all* potential users, regardless of degree of literacy or native language.
4. Warn against hazards of both use and foreseeable misuse.
5. Conspicuous; attention-demanding; urgent; *emphatic!*
6. Durable and legible; affix to product as well as to case or container.
7. Conform to standards but consider standards *minimum* requirements.
8. Pictures, symbols, diagrams, etc. okay, *if* universally understood and adequate.
9. Maintain currency; reflect latest design and user experience.
10. Use redundancy (warn in two or three ways, if possible).
11. Test effectiveness on *representative* sample of potential users.
12. Supplement warning with instruction and aperiodic reinforcement.

Train

The *training* in the five-word model breaks the order of precedence. Even the very best of designed products may still require training for safe, proper operation. Light aircraft are a good example, and most manufacturers of light aircraft do, indeed, offer at least "check-outs," even though the purchaser may be fully licensed. Unfortunately, this is not true of many of the products that enter the stream of commerce. While vendors might put themselves at risk by refusing to sell a product to consumers unless the consumers take a recommended training course, certainly few consumers would refuse an offer of free instruction in how to operate a product safely.

How are the training requirements to be determined? Again, a human factors psychologist can be of assistance. Such individuals specialize in the development of training requirements and training objectives, including the development of satisfactory methods for meeting those objectives. The development of these materials, which is accomplished most easily and effectively during the development of the product, presents yet another reason for thorough *testing* of one's products on samples of *representative users* under *representative conditions.* Testing should be followed by a thorough "field-use" program.

The conduct of the actual training will vary from situation to situation. It would seem that the designer-manufacturers would be in the best position to identify training requirements and to formulate training objectives. They may also be the ones best equipped to specify the educational means and methods that should be employed to fulfill the training objectives.

Often the manufacturer is too remote from the user to provide training. However, if training is determined to be necessary, the manufacturer should make this fact known to distributors and/or vendors. Together they must work out an acceptable solution.

Experience suggests that a particularly significant interaction exists between warnings and training. The startling statistics on the ineffectiveness of the warnings on cigarette packages and the fact that only 12 to 14 percent of passengers and drivers of motor vehicles "buckle up" lend substance to such concerns. It is strongly recommended that warnings be supplemented with appropriate training. While experimental evidence may be lacking, it is believed that appropriate warnings *plus* appropriate training will result in benefits to safety measured multiplicatively rather than additively.

Concluding Comments

It is realized that no simple five-word model can handle all the considerations that enter into the design, manufacture, distribution, and use of products. For example, the model says nothing about the *selection* of

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people who should be allowed to operate certain products. An interaction has been implied between warnings and training; there probably are others. The need for research to supplement opinion is quite evident.

However, this simple model, supplemented by appropriate methods and by the information from the field of human factors that is available but not being used, would contribute to the reduction of injuries and accidents that have been shown to result from ignoring these considerations. ●

Julien Christensen, Ph.D., Sci. Dr., is a former Chief of the Human Engineering Division of Armstrong Laboratory, and is currently Chief of Human Factors for Universal Energy Systems, Dayton, OH.

References

Hammer, W. (1976). *Occupational safety management and engineering.* Englewood Cliffs, NJ: Prentice-Hall.

Jones, D.F. (1973). *Human Factors-Occupational Safety.* Ontario, Canada: Ontario Ministry of Labour.

Wechsler, D. (1952). *The range of human capacities.* Baltimore: Williams & Wilkins.

Footnotes

[1] I am grateful to Hemisphere Publishing Corporation for permission to reproduce material that I prepared for Hemisphere's *Psychology in Product Liability and Personal Injury Litigation* (M.I. Kurke & R.G. Meyer, Eds., 1986).

Calendar

November 1-4, 1993
Arlington, VA, USA
"Information and Technology Teamed for Success" is the theme of the Annual Users' Training Conference sponsored by the Defense Technical Information Center (DTIC), Cameron Station, VA. Contact Patti Miller, (703) 274-3848, DSN 284-3848.

November 1-4, 1993
Arlington, VA, USA
Occupational Ergonomics: Work Evaluation and Prevention of Upper Limb and Back Disorders Course. Sponsored by the University of Michigan and the George Washington University and the Johns Hopkins Educational Resource Center in Occupational Safety and Health. Contact Conlin-Faber Travel, Inc., P.O. Box 1207, Ann Arbor, MI 48106; (800) 426-6546.

November 5-6, 1993
Arlington, VA, USA
Ergonomic Job Analysis Course. Sponsored by the University of Michigan and the George Washington University and the Johns Hopkins Educational Resource Center in Occupational Safety and Health. Contact Conlin-Faber Travel, Inc., P.O. Box 1207, Ann Arbor, MI 48106; (800) 426-6546.

November 7-11, 1993
Phoenix, AZ, USA
Color Imaging Conference. Sponsored by SIST, SID, and others. Contact Society for Imaging Science and Technology, 7003 Kilworth Lane, Springfield, VA 22151; (703) 642-9090, fax (703) 642-9094.

November 8-10, 1993
Las Vegas, NV, USA
1993 SAFE Symposium. Contact SAFE, P.O. Box 490, Yoncalla, OR 97499-0490; (503) 849-2977, fax (503) 849-2997.

November 14-18, 1993
Seattle, WA, USA
Hypertext '93. Sponsored by ACM SIGLINK. Contact Steve Poltrock, Computer Science Organization, Boeing Computer Services, P.O. Box 24346, M/S 7L-64, Seattle, WA 98124-0346; (206) 865-3270.

November 15-18, 1993
San Diego, CA, USA
31st Meeting of the Department of Defense Human Factors Engineering Technical Group (TG). Contact Louida D. Murray, TG Program Coordinator, 4476 W. Ponds View Dr., Littleton, CO 80123; (303) 798-2617, fax (303) 798-2617.

November 16-17, 1993
Alexandria, VA, USA
Eighth Federal Aviation Administration Meeting on Human Factors in Aircraft Maintenance and Inspection, "Trends and Advances in Aviation Maintenance Operations." Contact Bio-Technology, Inc., 405 N. Washington St., Suite 203, Falls Church, VA 22046; (703) 534-8200, fax (703) 534-2351.

March 16-20, 1994
San Antonio, TX, USA
EDRA 25, the 25th Annual Meeting of the Environmental Design Research Association. Contact EDRA Business Office, P.O. Box 24083, Oklahoma City, OK 73214; (405) 843-4863.

April 19-22, 1994
University of Warwick, UK
Ergonomics Society Annual Conference. Contact Conference Manager, Devonshire House, Devonshire Sq., Loughborough, Leichestershire LE11 3DW, UK; (44) 509-234904.

April 24-28, 1993
Boston, MA, USA
CHI '94: Association for Computing Machinery on Human Factors in Computing Systems. Contact Thomas Hewett, Drexel University, Dept. of Psychology/Sociology/Anthropology, Central Receiving, 33rd & Ludlow Sts., Philadelphia, PA 19104; (215) 590-8616.

May 8-12, 1994
San Antonio, TX, USA
Aerospace Medical Association 65th Annual Scientific Meeting. Contact Pamela Day, Aerospace Medical Association, 320 S. Henry St., Alexandria, VA 22314; (703) 739-2240. *Abstract deadline: October 22, 1993.*

Notices for the calendar should be sent at least four months in advance to:
CSERIAC Gateway Calendar, AL/CFH/CSERIAC Bldg 248, 2255 H Street, Wright-Patterson AFB OH 45433-7022

The COTR Speaks

Reuben L. Hann

Design! Remove! Guard! Warn! Train! These are the key components in a model for safer products which is featured in this issue as the second part of Julien Christensen's feature on Forensic Human Factors Psychology. You will remember from the last issue that Dr. Christensen detailed the role psychologists often play in the courtroom as a result of litigation stemming from poorly designed products. Application of Dr. Christensen's proposed model could result in safer products and court litigation would be less likely. In fact, his model can serve as a valuable tool for guiding design of any human-machine system—not just commercial products.

Good news! Please read the Letter from the Editor. Jeff Landis, *Gateway* Editor, has received permission from the Department of Defense to accept paid advertisements in *Gateway*. In his Letter, Jeff outlines our policy for commercial ads. As usual, we will continue to accept items for the calendar and other brief announcements at no charge.

The second speaker in the Human Engineering Division, Armstrong Laboratory Colloquium Series: The Human-Computer Interface, was Thomas A. Furness, III. A pioneer in virtual worlds, Dr. Furness spoke on "Cobwebs in a Virtual Attic." Robert Osgood of the Visual Display Systems Branch, Human Engineering Division, has written a synopsis of Dr. Furness' presentation. Following his presentation, I spoke briefly with Dr. Furness. An edited version of my conversation with him follows Dr. Osgood's article.

Have you ever wanted to assess a crew station design before the physical mock-ups were built? Well, the Army and NASA combined their efforts in the Aircrew/Aircraft Integration Program (A^3I) and developed MIDAS (Man-Machine Integration Design and Analysis System), a workstation intended to allow engineers, psychologists, and designers to assess cockpit designs *before* the hardware is built. Barry R. Smith and E. James Hartzell of the NASA-Ames Research Center discuss the development of MIDAS in this issue's government program article.

The featured product in this issue is our most recent State-of-the-Art Report (SOAR), *Naturalistic Decision-Making: Implications for Design*. The author, Gary Klein, has prepared a brief synopsis of this SOAR.

Completing this issue is an edited transcript of an interview that Arnold Wasserman gave Lawrence D. Howell, CSERIAC Associate Director, and Lt. Col. Elaine Howell, at the Air Force Human Systems Center Technology Forum, November 9-10, 1992.

As always, your suggestions and comments are welcome. Please forward them to:

CSERIAC Program Office
AL/CFH/CSERIAC Bldg 248
Attn: Jeffrey A. Landis, Editor
2255 H Street
Wright-Patterson AFB OH 45433-7022

Reuben "Lew" Hann, Ph.D. is the Contracting Officer's Technical Representative (COTR) who serves as the Government Manager for the CSERIAC Program.

Position Available

Senior Human Factors Analyst

CSERIAC has an immediate opening for a key analyst in crew system ergonomics/ human factors. Following are some of the preferred qualifications for the position.

- Ph.D. and 15+ years related experience in engineering or psychology with an emphasis on human factors.
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- Flexibility and versatility in response to changeable job duties.
- Military experience and/or knowledge of the DoD and government agencies.
- Good interpersonal skills (the ability to interact productively with people in government and industry, as well as coworkers).

For information about CSERIAC, contact Donald Dreesbach at (513) 255-4842. Send resumes to Robert Artman, University of Dayton Research Institute, Office of Human Resources, Kettering Laboratory 503, Dayton, OH 45469-0105.

GATEWAY

Letter from the Editor

Jeffrey A. Landis

Recently, the Defense Technical Information Center (DTIC), the government office which established the CSERIAC Program Office, granted permission for the *CSERIAC Gateway* to accept paid advertisements. Following is a statement of policy regarding such advertisements.

Paid advertisements will only be accepted for those products and services deemed to be relevant to CSERIAC's objective of acquiring, analyzing, and disseminating timely information on human factors and ergonomics. Relevant position announcements will also be accepted. The determination of relevancy will be made by the CSERIAC COTR, Dr. Reuben L. Hann. He reserves the right to reject all material deemed inappropriate for publication in *Gateway.*

Paid advertisements will not constitute more than 25 percent of the total number of pages for any given issue. Please note that only camera-ready artwork will be accepted and must be submitted a minimum of 30 days prior to the date of publication. Such advertisements will be allotted space in the following increments. Their associated cost/issue is included.

Full page	7.25" x 9"	$ 500
Half-page	7.25" x 4.5"	$ 300
Third-page	2.25" x 9"	$ 200
Quarter-page	4.75" x 4"	$ 150

The appearance of advertising in *Gateway*, including inserts or supplements, does not constitute endorsement by CSERIAC, the Department of Defense, or the University of Dayton. Furthermore, it shall not contain any material that implies that Department of Defense components or their subordinate echelons endorse or favor a specific commercial product, commodity, or service.

In addition, everything advertised in *Gateway* shall be made available for purchase, use, or patronage without regard to race, color, religion, sex, national origin, age, marital status, physical handicap, political affiliation, or any other nonmerit factor of the purchaser, user, or patron.

If a violation or rejection of this equal opportunity policy by an advertiser is confirmed, the Editor shall refuse to print advertising from that source until the violation is corrected.

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Announcements

DTIC's DoD Thrust Area Products

The DoD Thrust Areas deal with those capabilities considered essential for maintaining qualitative superiority of U.S. weapons systems.

Each Thrust Area Product includes references to technical reports and work unit summaries, as well as a listing of commercial databases containing information relative to that Thrust Area. The initial reports are retrospective documents that include citations with report/summary dates from 1990 through 1992.

DTIC has compiled two versions for each of the Thrust Areas. One version is available to DoD components only, and another version is available to DoD components and their contractors. The following lists DoD Thrust Area titles and the DTIC order numbers for each version:

Thrust Area 1, Global Surveillance and Communications
DoD Only: AD-B171 118
DoD & DoD Contractors: AD-B171 119

Thrust Area 2, Precision Strike
DoD Only: AD-B172 719
DoD & DoD Contractors: AD-B172 720

Thrust Area 3, Air Superiority and Defense
DoD Only: AD-B169 639
DoD & DoD Contractors: AD -B171 000

Thrust Area 4, Sea Control and Undersea Superiority
DoD Only: AD-B173 402
DoD & DoD Contractors: AD-B173 403

Thrust Area 5, Advanced Land Combat
DoD Only: AD B171 958
DoD & DoD Contractors: AD B171 959

Thrust Area 6, Synthetic Environments
DoD Only: AD-B172 101
DoD & DoD Contractors: AD B172 102

Thrust Area 7, Technology for Affordability
DoD Only: AD B173 400
DoD & DoD Contractors: AD B173 401

Each version is available in hard copy ($50) and microfiche ($4) formats.

You may order DTIC's Thrust Area Products by mail (DTIC, ATTN: DTIC-BCP, Cameron Station, Alexandria, VA 22304-6145); by calling DTIC's Reference Services Branch on (703) 274-7633/ DSN 284-7633; by facsimile (703) 274-9307/ DSN-9307; or via e-mail at the following address: msorders@dgis.dtic.dla.mil

(NOTE: Please address questions or requests for additional information or searches relative to the Thrust Areas to DTIC's Request Processing Branch. The staff of retrieval analysts may be reached on [703] 274-6867/DSN 284-6867).

Future plans include producing and disseminating Thrust Area information on a monthly basis. These "Recurring" Thrust Area products will include information accessioned into DTIC's databases within the previous 30-day period. That product will be available on a yearly subscription basis.

Please address any questions regarding this article to Ms. Pamela Shepard, DTIC Product Management Branch, on (703) 274-6434/DSN 284-6434.

Industrial Ergonomics Bibliography

The Human Factors and Ergonomics Society has revised its guide to the literature on industrial ergonomics, "Industrial Ergonomics Bibliography." The new brochure is free of charge and lists publications that contain data useful for the design of jobs in industry.

The bibliography is divided into six sections, in addition to lists of periodicals and proceedings: *General* lists texts and handbooks; *Worker Characteristics* covers size, strength, age, and gender; *Job Design* addresses productivity, human error, fatigue, and accidents; *Equipment Design* concerns displays, controls, and tools; *Workplace Design* includes information on chairs, benches, floors, and stairs; and *Environmental Design* covers heat, noise, vibration, and illumination.

The bibliography is designed for human factors practitioners, industrial engineers, safety professionals, occupational physicians and nurses, industrial hygienists, personnel specialists, managers, labor union officials, and workers.

To obtain a free copy of the "Industrial Ergonomics Bibliography," contact the Human Factors and Ergonomics Society, P.O. Box 1369, Santa Monica, CA 90406-1369; (310) 394-1811, fax (310) 394-2410.

Certification for Ergonomists and Human Factors Professionals

The Board of Certification in Professional Ergonomics is now accepting applications for professional certification of ergonomics and human factors practitioners. Applicants should have a mastery of ergonomics knowledge and methods, as well as expertise in the analysis, design, and evaluation of products, systems, and environments for human use. Qualified applicants may choose to be certified as either Certified Professional Ergonomists (CPE) or as Certified Human Factors Professionals (CHFP). Applications are available from Board of Certification in Professional Ergonomics, Office of the Executive Director, P. O. Box 2811, Bellingham, WA 98227-2811, USA, phone: (206) 671-7601 fax: (206) 671-7681.

Minimum qualifications are an MA/MS or equivalent in ergonomics or a closely related field and 7 years of demonstrable experience in the practice of ergonomics. Applications are open to ergonomists internationally.

Certification will be based on an evaluation of work samples and supporting documentation through December 31, 1993. The application processing fee is US$200 (nonrefundable) with an annual renewal fee of $75. After December 31, 1993, applicants will be required to pass a written examination.

The Board of Certification in Professional Ergonomics was formed as a nonprofit corporation in 1990. Although the Board was established with support from the Human Factors Society, it is independent of any professional, scientific, or trade association.

Current members of the Board are Alphonse Chapanis, Ph.D; David Meister, Ph.D.; Melvin H. Rudov, Ph.D.; Hal W. Hendrick, Ph.D.; George A. Peters, J. D.; H. Harvey Cohen, Ph.D.; David J. Cochran, Ph.D.; Jerry R. Duncan, Ph.D.; Steven M. Casey, Ph.D. The Executive Director is Dieter W. Jahns, M.S.

Human Engineering Division, Armstrong Laboratory Colloquium Series

Cobwebs in a Virtual Attic

Thomas A. Furness
Synopsis by Robert K. Osgood

Editor's Note: Following is a review of a presentation by Dr. Thomas A. Furness, III, as the second speaker in the 1993 Human Engineering Division, Armstrong Laboratory Colloquium Series: The Human-Computer Interface. This synopsis was prepared by Dr. Robert K. Osgood, Research Psychologist with the Visual Display Systems Branch, Human Engineering Division, Armstrong Laboratory. JAL

Dr. Thomas A. Furness III returned to his professional alma mater once again to reminisce and share his feelings about interfaces and events happening in the world and at the University of Washington. He began by sharing his own personal experiences, which he does so willingly, to weave a simple story with a significant plot. This story started with the empty nest syndrome and its effect on his life. Tom's children had grown and left home,which led him to take an art class to fill his time. That art class, in turn, led to self-observational correction. Although he knew how to draw, what he didn't know was how to "see." This brought to Tom's mind the whole problem of taking into account the tremendous capabilities humans have and then using that knowledge to build interfaces that optimize those capabilities. How much easier it would be if humans could rely on their own senses when interacting with machines as opposed to learning to interpret the various gauges and dials attached to them.

An important question Tom asked himself was "How are we going to manage the amount of knowledge and information that exist?" According to some people the computer is going to

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Resolution	4000 x 3000 elements
Stereo overlap	70%
Field-of-view	120° H by 70° V
Accommodation (static)	-2.0 to +2.0 diopters
Color	red, green, blue
Weight	~100 gms
Cost	$2000

Figure 1. Performance requirements for a virtual retinal display.

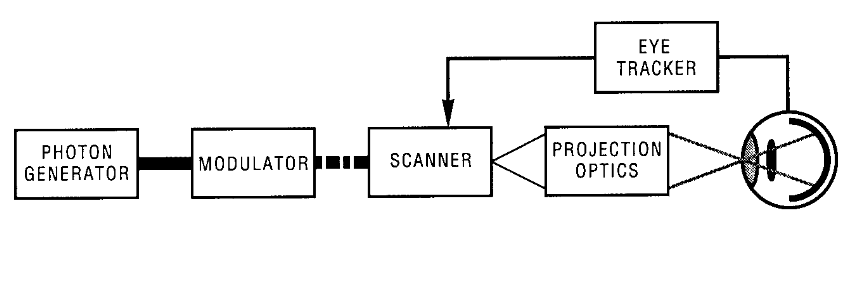

Figure 2. Schematic drawing of a virtual retinal display.

solve all those problems. Craig Fields, Director of the Defense Advanced Research Projects Agency, predicted that by 1996 a computing capacity of one Cray per cubic centimeter would exist and by 2005 a computing capacity of 10^6 Crays per cubic centimeter would exist. The question now became "How are we going to interface it with the human and who is going to program it?" Tom's answer to this interface question is "...break the glass and put the human inside."

In 1965, one of the early pioneers, Ivan Sutherland, had a vision of what is now called virtual environments. He claimed that "In a virtual environment the medium disappears and the message and the environment become the same." In other words, virtual images are presented directly to the senses, and the senses respond by interacting directly with the environment. Tom's first experiment in building such an environment was with VCASS (Visually Coupled Airborne Systems Simulator at the Human Engineering Division of the Armstrong Laboratory). He likened the day it was turned on to the day when Alexander Graham Bell said "Mr. Watson come quickly!" when speaking into the first telephone. The start-up of VCASS ushered in a whole new world for humans interacting with machines.

Traditionally, various media have placed humans on the outside, looking in. For the first time, VCASS allowed people to go inside the medium and actually experience the environment. People could now experience a world that was synthesized by the computer and portrayed in a way that allowed them to interact with it.

They could move around, control objects, and change the physics of the environment.

This particular type of interface empowers humans to use their innate abilities, their 3-dimensional architecture. Concerning applications, it can open up whole new dimensions in the ability to teach experientially, solve problems in medicine by allowing people to visualize complex scientific data, and create prototyping environments where people design as well as solve some of the pervasive problems for the learning and physically disabled. Such possibilities motivated Tom to establish an organization dedicated to studying virtual environments.

The Human Interface Technology (HIT) Laboratory was created in 1989 by the Washington Technology Center at the University of Washington, Seattle. Its mission is to explore human computer-interface technology; create new application areas for virtual world technology in aerospace, education, medicine, design, communications, and entertainment; and transform virtual world concepts and research into practical marketable technology.

The HIT Laboratory, in conjunction with the Massachusetts Institute of Technology (MIT), is advancing virtual reality technology. Together they are building a virtual retinal display which is a Maxwellian-view optical system using a photon generator to modulate a stream of photons such that the projection screen or the image plane is the retina of the eye. The technology takes a helium neon laser through an acousto-optical scanning system and scans that onto the retina of the eye. Figures 1 and 2 depict this virtual retinal display.

Another cooperative project for the HIT Laboratory involved the Pacific Science Center where a Technology Academy was established. It is a summer camp for children 9-14 years of age where they are challenged to build their own virtual worlds. An interesting finding is that the children tend to develop worlds where there is very little violence. They want peaceful worlds with exciting experiences and educationally oriented environments. The Academy has also been used successfully with children considered "at risk" because of the inner-city environments in which they live.

As an outgrowth of his work with virtual reality and the HIT Laboratory, Tom has established the Virtual World Society (VWS) whose mission is to promote education and development of computing and interface technologies for the benefit of the individual and society as a whole. VWS is futuristic in nature, addressing computing issues into the 21st century. The table lists some of the various activities with which VWS is involved. If you are interested in joining VWS, please contact the CSERIAC Program Office for a registration form. ●

Virtual World Society Activities

1. Fund university research (as gifts/grants).
2. Support scholarships for undergraduate and graduate students.
3. Provide equipment/software to school districts.
4. Fund virtual computer science/electronic labs in elementary and high schools.
5. Conduct summer camp/internships for young people.
6. Publish magazine/newsletter.
7. Serve as nexus for virtual worlds (public domain software).
8. Fund television specials.
9. Create virtual communitites/virtual science cities.
10. Encourage increased federal support.
11. Leverage the development of technology.

Human Engineering Division, Armstrong Laboratory Colloquium Series

A Conversation with Thomas A. Furness

Reuben L. Hann

Editor's Note: The following is an edited transcript of a conversation with Dr. Thomas A. Furness, III, University of Washington, who had just made a presentation as the second speaker in the 1993 Human Engineering Division, Armstrong Laboratory Colloquium Series: The Human-Computer Interface. The interviewer was Dr. Lew Hann, CSERIAC COTR. JAL

CSERIAC: I see that you are affiliated with the "Human Interface Technology Laboratory" at University of Washington. Are you the founder of this lab?

Dr. Furness: Yes. While I was still here at Wright-Patterson I took a sabbatical, during which I worked on establishing an investment strategy for the Air Force, to help determine where they should go in this particular technology area. I visited government installations, hospitals, toy companies—a whole variety of places. I came back with the feeling that what we really needed in this country was a way to get the technology out of the military to these other settings.

After visiting all these places, it was clear to me that a lot of work was going on in computing—speed and capacity were increasing remarkably. But no one was working on how to interface all this new capability to the human; that is, how to get beyond what we use today—the normal terminal and keyboard. So I put together a plan for a national laboratory somewhere in the United States which would work on human interface technology. Then I went looking for a place to set it up. I visited a variety of institutions, such as Carnegie-Mellon, MIT, University of Texas, Wright State, University of Utah, Ohio State, University of Dayton, Cal Tech, Stanford, University of Washington, and UC Berkeley.

CSERIAC: How did you settle on University of Washington?

Dr. Furness: Washington had a unique combination of attributes which I thought would provide a fertile ground for setting up this new laboratory. First of all, it had a good industrial base, with the Boeing Company and Microsoft. In fact, the area around Seattle has the highest *per capita* percentage of software experts in the world—about 300 software companies at this time. Another important factor was that the University had a good college of engineering as well as a medical school, was very well funded, and research-oriented. Then there was the Washington Technology Center. This is a state research institute which tries to link the academic and industrial sides of the state. Such institutions have been established or are planned in other states as well. I think government is beginning to realize that the real resource for technological innovation in the future will be the university.

CSERIAC: Is the application of virtual reality techniques to real-world problems just hype? That is, can it live up to the promise?

Dr. Furness: As far as the technology itself is concerned, I think it will come along fine. It just needs to be done in a systematic way. The hardware and software technology will happen; what I am really concerned about is the human factors aspect.

CSERIAC: Really? What kind of problems do you think need to be studied?

Dr. Furness: There are a number of concerns in the software area. For example, no one really knows the longitudinal effects of going into a virtual world and staying there for a long time. Whenever you deviate from the real world—when you are immersed in an inclusive environment—you have to be very careful how you provide stabilization of the images. Otherwise, you could really "scramble" someone's brains. The person in this environment has to adapt to the reduced resolution and increased latencies of the images. We are concerned not only with how persons adapt to this other world, but also how they readapt to the real world after an extended period in the virtual space.

"...no one really knows the longitudinal effects of going into a virtual world and staying there for a long time."

CSERIAC: This sounds like some of the issues dealt with by space psychologists in the astronaut program.

Dr. Furness: Exactly. With virtual reality we need to have the same kind of research done as was carried out in the areas of space adaptation and readaptation upon return to earth. There is a wealth of work which needs to be done. I don't see it being accomplished

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in industrial laboratories; it needs to be done in governmental and university laboratories, where they can deal with the basic scientific issues.

CSERIAC: One of the technical problems, which came out in your presentation today, continues to be the difficulty of providing touch feedback.

Dr. Furness: We certainly still have a lot of work to do in visual and acoustic interfaces, but they are relatively mature technologies. However, the only way virtual environments will be productive and useful—in that we are able to use our natural, innate three-dimensional motor skills—is to be able to have a good haptic interface. This means not only providing a method for measuring movement that will control objects, but getting the tactile and force feedback you would have in the normal world. Much more work needs to be done in this area.

CSERIAC: I understand you are the founder of a relatively new organization called the *Virtual World Society.* Could you tell us a bit about it?

Dr. Furness: Certainly. Basically, the purpose of the *Virtual World Society* is to promote computing and people. As we approach the 21st century we have the opportunity to empower people to accelerate their ability to learn, to be able to create more effectively, to be able to communicate better, to operate complex systems, as well as to help people who have physical or learning disabilities. This is all going to happen in the way we interface humans to computers, I believe.

So the purpose of the *Virtual World Society* is to promote the empowerment of humans through computing—in particular, people who are not "professional." We are talking about everyday men, women, and children. I am not saying that we will train them to become "computer-literate." Rather, I believe the computer will become

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Scenes from the Human Engineering Division, Armstrong Laboratory Colloquium Series:

Dr. Furness attracted the largest crowd in two years of the Colloquium Series.

The crowd was so large, in fact, that some attendees had to sit on the floor for a lack of chairs!

A^3I: Building the MIDAS Touch for Model-Based Crew Station Design

Barry R. Smith
E. James Hartzell

An often-cited fact of weapon system development is that seventy to eighty percent of the life-cycle cost of an aircraft is determined in the conceptual design phase. The early design and operational decisions frequently dictate the manufacturing, logistics, and training concepts which drive downstream costs.

While the Army's rotorcraft designers and engineers have numerous model-based analytical techniques to prototype and test initial concepts before committing to hardware, the engineering psychologist often lacks adequate methods to assess cockpit designs until physical mock-ups are produced. By waiting until hardware is built to perform empirical tests, the mistakes they find can be costly to correct and the vehicle design concepts difficult to modify.

With this strong incentive, the Army-NASA Aircrew/Aircraft Integration Program (A^3I) and its Man-Machine Integration Design and Analysis System (MIDAS) workstation, seek to provide opportunities to "see it before you build it," to ask "what if" questions about all aspects of crew performance, and to correct problems before they progress to hardware.

Under the Aeroflightdynamics Directorate of the U.S. Army Aviation and Troop Command, A^3I shares facilities and personnel at Moffett Field, CA, with the NASA Ames Research Center in rotorcraft simulation, structural dynamics, fluid mechanics, and human factors. Begun in 1984, A^3I is an exploratory development effort to advance the capabilities and use of computational models of human performance in the design, synthesis, and analysis of advanced aviation crew stations.

The Program conducts and integrates applied research to develop a unique systems-engineering environment. This environment, similar to traditional Computer-Aided-Engineering (CAE) systems, contains tools and models to assist crew station developers in the conceptual design phase. While such systems have previously been developed by using Finite Element Analysis (FEA) or Computational Fluid Dynamics (CFD), A^3I's aim is to develop a CAE system with a human factors engineering focus.

At the core of the design aiding system is MIDAS, a powerful workstation providing the interactive symbolic, analytic, and graphic components to integrate and visualize human engineering principles. As depicted in Figure 1, MIDAS contains tools to describe the operating environment, equipment, and mission of manned systems, with embedded models of human performance/behavior to support static and dynamic "what if" evaluations of the crew station design and operator task performance.

Information is typically presented graphically, often as a computer simulation of "manned flight." In this sense, MIDAS is similar to existing tools such as CFD. However, unlike CFD or FEA, human factors engineering requires not one or two scientific disciplines, but over a dozen. Good human factors engineers must not only deal with the acoustic, life support, vision, anthropometry, motor, and cognitive demands placed on the intended op-

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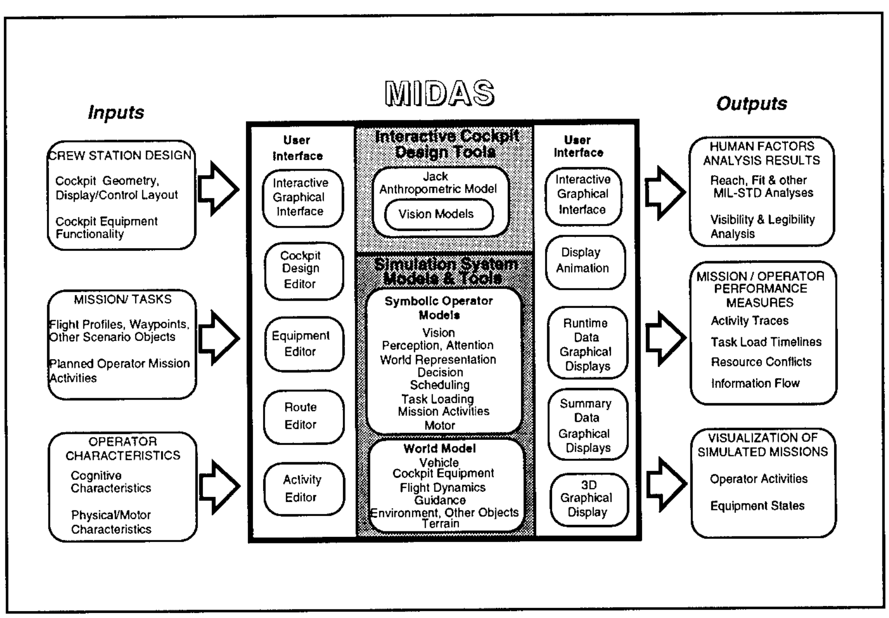

Figure 1. MIDAS top-level functionality.

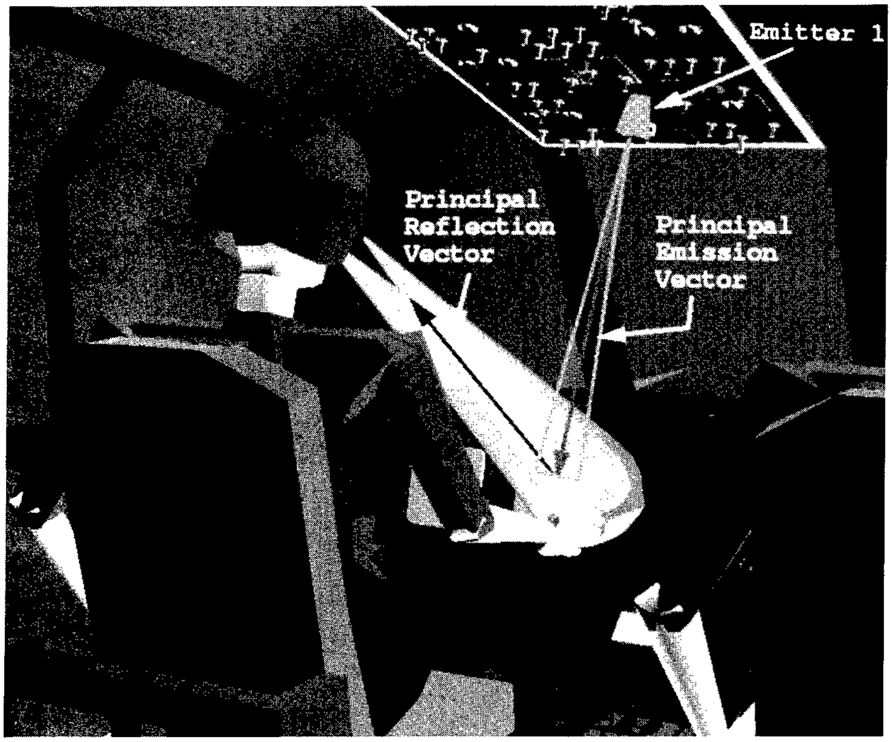

Figure 2. MIDAS anthropometry and vision models.

erator, but also must address input from avionics engineers related to the physical design, function, and operation of the crew station.

MIDAS accommodates these varied needs by relying upon a unique distributed computational architecture. Many small models of human behavior and performance are employed collectively, rather than a single, mega-model of a simulated operator. Similarly, through object-oriented programming techniques, environmental and equipment models can be developed with varying levels of abstraction depending on the specific answers sought.

Aside from the computational benefits, this approach allows incremental development and testing—an absolute must considering the complexity of present advanced technology systems. While certain types of assessments supported by MIDAS, such as "reach and fit" using a 3-D human anthropometry model produced by the University of Pennsylvania (see Fig. 2) are quite robust today, others, particularly those in the cognitive and task performance areas, are relatively nascent, requiring considerably more research before they are useful to practicing designers. In this manner, MIDAS has served as the framework for a wealth of human performance modeling and research pursued by Ames Research Center.

During the past two years, the A^3I team has been involved in a Technology Exchange Agreement with Boeing Helicopters Division. The agreement's objective is to transition as much of the extant MIDAS code to Boeing as is feasible for use in their human engineering design process. In return, Boeing provides "real world" user feedback, detailed design and operating requirements, and applications data to the Ames researchers. The MIDAS team has also recently been applying the system to 911 dispatch console layout, through a Corporate Research and Development Agreement with a local company. Both applications have been useful honing exercises.

A^3I is nearing completion of its sixth major phase of development, toward a 1995 target date for a full prototype system. By providing human factors engineers with such tools and techniques as MIDAS, life cycle costs can be reduced and human performance improved by allowing an early and principled assessment of human-systems integration. ●

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Barry R. Smith is the A^3I/MIDAS Project Manager and E. James Hartzell is the Chief of the Computational Human Engineering Research Office, Ames Research Center, Moffett Field, CA.

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"transparent," much like modern automobiles, VCRs, microwave ovens, and other things in our lives which have computers as an integral part of them. When we think about computing and advanced interfaces, we still see the machine there. Well, the idea of virtual worlds is to make the machine, the medium, disappear—to where we are mainly concerned with the task we are trying to perform, whether it is learning, operating, designing, or whatever.

What we want to do is involve kids, as well as interested adults, and work at that level. The *Virtual World Society* will be building a "global" virtual world, a way to link people together, and to empower them to learn and to associate with each other, and create together. The goal is to promote a spirit of cooperation in the world, to help solve pervasive problems such as hunger, the environment, disease, and illiteracy. These are the things I want to perform which I have in this vision.

I have been able to gather a number of prominent people to serve on the board of directors of this not-for-profit organization. We want to convince millions of people to subscribe, much as they would for the Audubon Society or the Cousteau Society. But in this case we are trying to save *people,* rather than the whale. ●

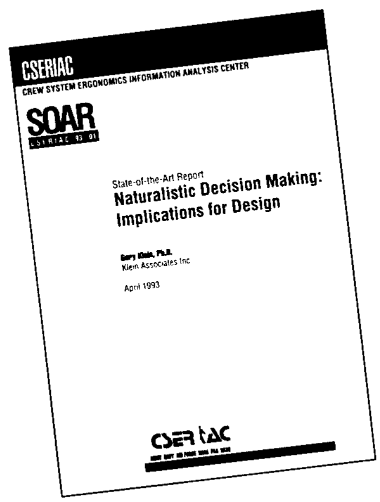
Naturalistic Decision Making: Implications for Design

Gary Klein

As information systems become more sophisticated, they are playing an increasing role in tasks such as decision making. Therefore, system developers need to understand how operators think, make decisions, and solve problems to support these processes more effectively. For years, behavioral scientists have urged designers to take into account human factors issues concerning visual angle, color, and brightness. Good progress has been made on these topics. Now we have to prepare guidelines for designing systems that will help —not obstruct—operators as they make judgments and decisions. Clumsy automation can appear to make the operator's job easier during routine events, but actually increase workload during emergencies.

The current state of knowledge about operator decision making and how this knowledge can help designers has been documented in a new state-of-the-art report (SOAR) produced by CSERIAC. This SOAR explains how to identify decision requirements and how to incorporate them into the design process. The report also describes tools for identifying decision requirements.

The field of naturalistic design making is a recent approach to describing how system operators actually make judgments and decisions, during emergencies as well as routine conditions. We are now in a position to identify decision requirements for performing difficult tasks. Design engineers can use decision requirements to formulate more focused systems, more robust interfaces, and better decision support. These decision requirements can become part of the specification process. Decision requirements can be identified during early concept development to shape the program objectives; during the preparation of specifications to influence the design; during test and evaluation to determine the adequacy of the system; and during redesign to apply the lessons learned about decisions that were not supported by the original concept.



Naturalistic Decision Making: Implications for Design.

The intended audience includes system developers and design engineers. The audience also includes human factors professionals who are interested in broadening the range of support they can offer during the development process.

The early chapters of the SOAR review recent work describing strategies on which people rely. The SOAR describes strategies people use for situation assessment for diagnosing problems. The report discusses how stress affects the decision making of both individuals and teams. It covers methods for identifying decision requirements, particularly the techniques available for cognitive task analysis, to understand how the operator is making inferences and judgments. The final chapters examine ways of applying naturalistic decision making to design, incorporating it within the cognitive systems engineering framework, along with topics such as memory, attention, and workload. Each chapter includes examples drawn from domains such as aviation, air combat, and manufacturing.

Naturalistic Decision Making: Implications for Design is available from the CSERIAC Program Office for $35. Author: Gary Klein, Klein Associates. ●

Gary Klein, Ph.D. is the Chairman and Chief Scientist of Klein Associates, Fairborn, OH.

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Ideas and Opinions of a Human Factors Pioneer: An Interview with Arnold Wasserman

Lawrence D. Howell, Jr.
Lt. Col. Elaine Howell

Editor's Note: The Human Systems Center (HSC) hosted a technology forum at Brooks Air Force Base, TX, November 9-10, 1992. The keynote speaker was Mr. Arnold Wasserman. Following his address, he gave a brief interview for the CSERIAC Gateway. The interviewers were Dr. Lawrence D. Howell, Associate Director for CSERIAC, and Lt. Col. Elaine Howell, Chief of Human Resources, Human Systems Integration Technical Planning Integrated Product Team, Human Systems Center, Brooks Air Force Base. Following are edited excerpts from that interview. JAL

CSERIAC: When do you think human factors became a respected profession? or has it? will it?

Mr. Wasserman: There is no question in my mind that, at least in commercial products, human factors has become a very respected profession, because it is viewed as one of the major remaining opportunities for competitive advantage. The assumption is that the top Japanese companies in consumer products, like Sony, Sharp, Panasonic, even if they are viewed as technology leaders by their competitors, don't feel it's safe to view themselves as technology leaders. The president of Sony said "We assume that all of our competition will have technology, price, services, and features as good as ours. The only differentiation we can rely on for sustainable competitive advantage is design." It has become clear to just about everybody, particularly in consumer products, and increasingly in industrial and commercial products like medical equipment and industrial process systems, that ergonomics underlies human-centered design. There are now many more opportunities for first-rate human factors professionals.

CSERIAC: What do you consider the high point of your human factors career?

Mr. Wasserman: Probably the work I did at Xerox from 1980 to 1986 — completely redesigning the Xerox copier products line for the next five to ten years, based on integration of industrial design, human factors, communications design, and grounded in basic research in how people use complex systems in workplace environments, which came from the Palo Alto Research Center. It was a truly interdisciplinary design experience. It proved that unlike what is usually supposed, human factors scientists are not the accountants of design, and industrial designers are not the artists of design, but that they both have a lot to offer to one another. When they work together, there is nothing more magical than the results they can produce.

CSERIAC: Do you see parallels between industry and government research in human-centered technology?

Mr. Wasserman: I was surprised at the degree of congruence between the interesting research that was being pursued in private industry as well as universities and government, particularly questions like: what underlies the process of learning? how do people learn? how do different people learn differently? and in what way should education and training be presented? In the exploration of the virtual world there is a lot of work like head-up displays, for troubleshooting technicians in the field — like repair persons with a small head-up display that will give them instructions from a whole repair manual. Almost every research vector that I saw at Brooks (Air Force Base) has a counterpart in industry, especially those that are critical, like aerospace medical research.

CSERIAC: When you lecture on design theory, do you stress differences between U.S., European, and Japanese corporate cultures or environments?

Mr. Wasserman: Very much so. The area is of such interest to me because over the past fifteen years I've spent a lot of time in Japan, as well as in Europe, and I worked for three years in a French design office in the early 1960s. I'm very much interested in the differences and issues between design in different cultures. I give a great deal of attention to the subject, and one of the things that interests me most is that it is becoming more and more difficult to say just what a German or Japanese or American product is. When I first began working as a designer in the early 1950s, an American product was designed, planned, managed, and manufactured all in one place....NCR in Dayton, Ohio; Xerox in Rochester, New York; and they were distributed almost exclusively in the U.S. because foreign sales didn't pay high dividends. Today everything is different. A product today, for in-

stance, is designed by a British designer working in San Francisco for a Japanese company, manufactured in Taiwan, using optics from Germany and software from Scotland, assembled in Brazil, and sold under different labels in Japan, the U.S., and Europe. So, tell me, what is an American product? A German product? A Japanese product? It's become a really tough question. Did you know that the most successful Japanese cars in the United States today were all designed by American designers, working in advanced concept development labs in Southern California that the Japanese started in the mid-1970s? The Honda Civic, the Honda CRX, the Mazda Miata, the Toyota Celica, the Infiniti, and the Lexus, were all designed by American designers working for Japanese companies in Southern California. So, what's an American product?

CSERIAC: If you were to mentor a young human factors engineer, what would you stress as most important in career development ?

Mr. Wasserman: I think it helps to go into a large organization for a couple of years, a place like Brooks Air Force Base or a large university or corporation, and soak up as much information as possible. After three to five years, then go into smaller start-up ventures, for by then you will almost certainly have identified a software product or application that you've invented along the way, or a special development tool so you can go into that business yourself and become an entrepreneur. A lot of human factors people, like a lot of engineers, don't really have an entrepreneurial instinct, so if you don't — don't do that! I think moving around and not staying in one place, and particularly not staying only in a university research environment is really important. There's something about university research that's good for early preparation: access to facilities, getting grants, and publishing papers — but in a way it almost disables you for private industrial practice if you stay there too long. Also, gain lots of experience working with people other than human factors professionals as early as you can. Don't surround yourself only with like-minded people and develop a kind of "bunker mentality" — us versus them. Get out with business people and other product developers. Spend lots of time with customers other than with your direct laboratory observation subjects. Become as cosmopolitan and broad-minded as possible. Then you'll be able to take advantage of what I see as a major boom in the intelligent and effective use of human factors in every type of product category that I can think of.....industrial, environmental, and certainly in defense.

CSERIAC: How will more careful attention to human factors concerns help high-tech firms develop and market products to be competitive against foreign products?

Mr. Wasserman: The U.S. has a couple of leverageable strengths in the competitive marketplace: one is use of information technology, because we've led the world in information technology until recently. The other one is human factors expertise that comes out of military and industrial applications. I think that we can leverage those strengths for both physical human factors and cognitive human factors primarily by using superior human interface design for software user interfaces. We still lead the world in conceptual software development and user interface design, and we have to get better at that, faster than anybody else, because it's a sustainable competitive advantage. Human factors lies at the very center of user interfaces that are intuitive, easy to use, and that simplify complex systems. The U.S. really has to pay attention to nurturing its human factors edge and its potential human factors edge, particularly with respect to software interface design.

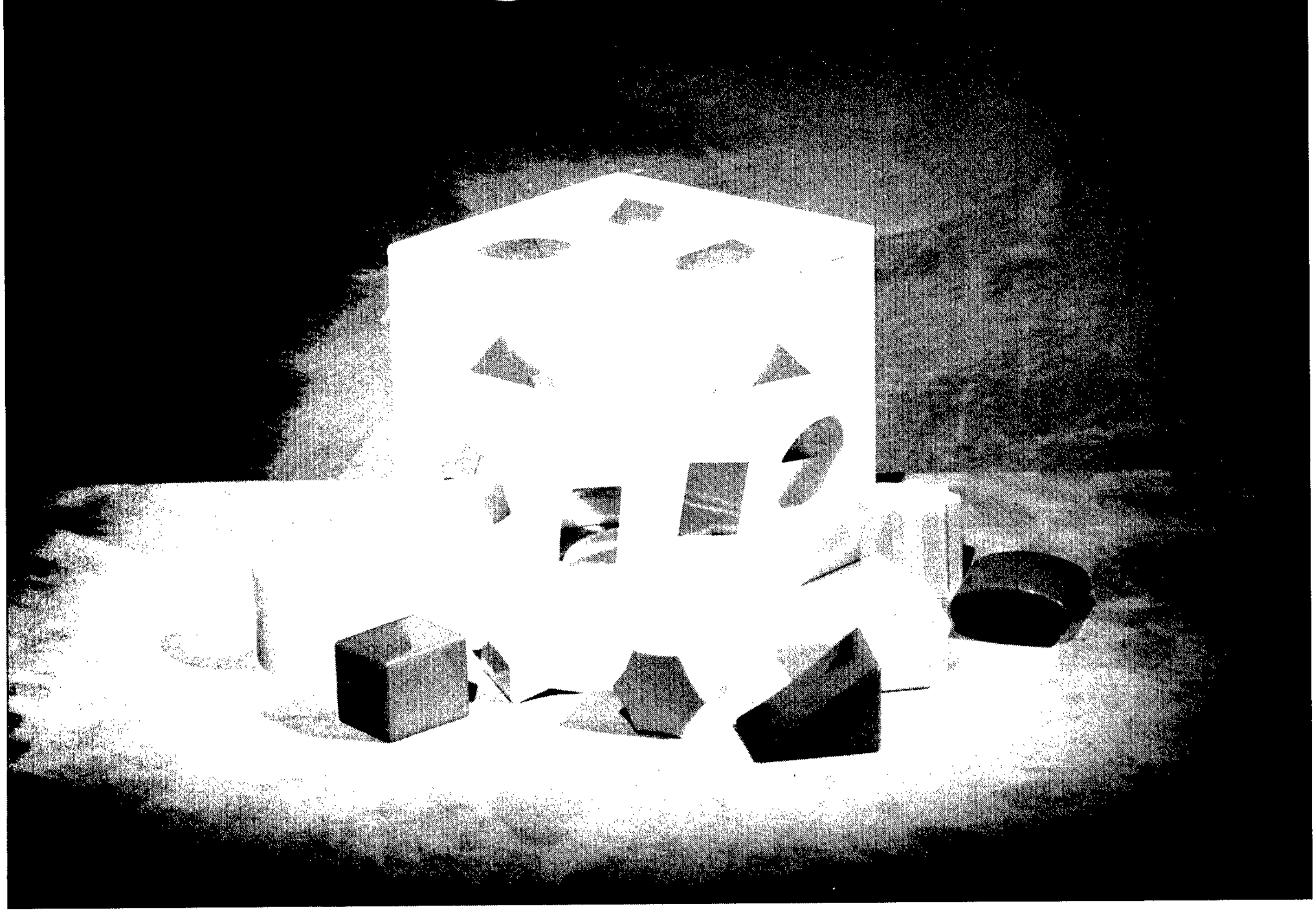
CSERIAC: Are you familiar with the concept of concurrent engineering? Do you believe this is something new? What is the value for human factors or design specialists?

Mr. Wasserman: The term is new but the fact certainly isn't new. New ventures and entrepreneurships support concurrent engineering simply by the fact that everybody works on everything all the time. This is especially true in small businesses. People are interchanging functions — like "I'm answering the phone now, because the phone needs answering." — not — "I'm answering it because I'm in the phone answering department." "I'm packing stuff to be shipped, because stuff needs to be packed, not because I work in the shipping department." Like the guy who opens up in the morning and takes a broom and sweeps the place out — that's how small ventures work. The idea of everybody talking to everyone all the time. You get all the downstream information flowing upstream in the product acquisition process. It's not a problem when it's small enough. There certainly is a time when it needs to be departmentalized functionally; then you begin to get serial hand-offs of projects from one department to another. People are interested in their own specialization and they begin to get "tribal" about the culture of their separate departments and you start to get rivalries; things begin to go wrong. The engineers blame the marketers for asking for stuff that can't possibly be done. The manufacturers blame everybody for not understanding what it takes to manufacture products. When that happens you have to call time out and say "OK, everybody!" You have to break down into functional departments, create matrix organizations where people all work together on a given project. It's absolutely essential to coordinate life-cycle development so you don't get churn or sabotage from one discipline to the

Continued on page 18

other. Team building across disciplines is very delicate. You can mismanage an interdisciplinary team as easily as you can mismanage a functional department; it's a very delicate sociological process. To say you've got concurrent engineering doesn't mean you've really improved anything. How the dynamics work — really understanding what it takes to get people from different disciplines to support one another and understand themselves as being interdependent — is a tricky business. The real thing is indispensable to success. Saying we've got product teams for concurrent engineering is just like saying we have total quality management but just giving lip service to it, without doing the hard work to really make it happen. ●

Mr. Wasserman served as Dean of the School of Art and Design, Pratt Institute; Vice President of Corporate Industrial Design, Human Factors, UNISYS Corporation; and Director of Corporate Industrial Design, NCR Corporation. He currently works as an independent consultant in San Francisco, CA.



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